Chapter 9

WATER QUALITY AND TREATMENT

An important interrelationship exists between water quality and human activities, including the withdrawal of water for supply. Increased withdrawals may cause a rise in the concentrations of impurities in the remaining water. Other human activities such as waste deposal or pollution spillage have the potential of degrading ground and surface water systems.

There are standards of quality that must be met for different types of uses. These standards are based on health or water use technology requirements; water frequently needs treatment in order to meet these standards. Technology can also be employed to augment and make the most of available water resources.

WATER QUALITY STANDARDS

Drinking Water Standards

There are two types of drinking water standards, primary and secondary. Both of these standards are the maximum contaminant levels for public drinking water systems. Primary drinking water standards include contaminants which can pose health hazards when present in excess of the maximum contaminant level (MCL). Secondary drinking water standards, commonly referred to as aesthetic standards, are those parameters which may impart an objectionable appearance, odor or taste to water, but are not necessarily health hazards. Current Florida Department of Environmental Protection (FDEP) primary and secondary drinking water standards are presented in Appendix H.

The U.S. Environmental Protection Agency (U.S. EPA) is anticipated to establish MCLs for trihalomethanes (THMs) that may be as low as 0.005 mg/L for individual THM compounds, but not higher than 0.05 mg/L for total trihalomethanes (TTHMs). The anticipated strengthening of the current trihalomethane MCL may have an impact on public water supplies in the UEC Planning Area. Most systems in the planning area have been able to meet the current THM standard of 0.10 mg/L by modifying or optimizing operation of their treatment and/or disinfection processes. THM concentrations in some cases are close to the current MCL of 0.10 mg/L. Some utilities in the planning area will have difficulty in meeting more stringent THM standards without some plant modification.

Nonpotable Water Standards

Water for potable and nonpotable water uses have different treatability constraints. Each type of water use has certain water quality requirements which, if violated, render the water source useless. Nonpotable water sources include surface water, ground water, and reclaimed water. Unlike potable water, with very specific quality standards to protect human health, water quality limits for nonpotable uses are quite variable and are dictated by the intended use of the water. For example, high iron content is usually not a factor in water used for flood irrigation of food crops, but requires removal for irrigation of ornamentals, which if iron stained, are not marketable. Excessive iron must also be removed for use in micro irrigation systems which become clogged by iron precipitate.

Nonpotable water uses include agricultural, landscape, golf course, and recreational irrigation. This water may also be acceptable for some industrial and commercial uses. For a source to be considered for irrigation for a specific use, there must be sufficient quantities of that water at a quality that is compatible with the crop it is to irrigate. Agricultural irrigation uses require that the salinity of the water not be so high as to damage crops either by direct application or through salt buildup in the soil profile. In addition, constituents that can damage the irrigation system infrastructure or equipment must be absent or economically removable. Water used for landscape, golf course, or recreational irrigation uses often has additional aesthetic requirements regarding color and odor. Irrigation water quality requirements are summarized in Appendix H.

In addition to water quality considerations associated with the intended use of nonpotable water, reclaimed water is subject to wastewater treatment standards which ensure the safety of its use (see Appendix I). As with any irrigation water, reclaimed water may contain some constituents at concentrations that are not desirable. Problems that might be associated with reclaimed water are no different from those of other water supplies and are only of concern if they hinder the use of the water or require special management techniques to allow its use. A meaningful assessment of irrigation water quality, regardless of the source, should consider local factors such as the specific chemical properties, the irrigated crops, climate, and irrigation practices.

GROUND WATER CONTAMINATION AND IMPACTS TO WATER SUPPLY

The SAS is easily contaminated by activities occurring at land's surface in the UEC Planning Area. Once a contaminant enters the aquifer, it may be cumbersome to remove. In many cases, leaks, spills or discharges of contaminants migrate over long periods of time, resulting in contamination of large areas of the aquifer. The preferred method of addressing the issue of water supply contamination, therefore, is to prevent contamination of the aquifer, and protect public water supply wells and wellfields from activities that present a possible contamination threat.

Ground Water Contamination Sources

There are many potential ground water contamination sources in the UEC Planning Area. These include solid waste sites, hazardous waste sites, Superfund Program sites, and septic tanks. All contamination sites do not necessarily contain contamination.

Solid Waste Sites. Landfills, old dumps and domestic sludge-spreading sites within the boundaries of the UEC Planning Area are listed in Table H-3, with an accompanying location map included as Figure H-7. The sludge spreading sites are included for reference, although not classified as landfills or dumps. These are usually tracts of land, often open range or citrus, where domestic wastewater treatment plant (WWTP) sludge is spread and incorporated into the soil.

Many of the older landfills and dumps were used for years with little or no control over what materials were disposed of in them. Although most have not been active for some time, they may still be a potential threat to the ground water resource.

Ground water beneath most unlined landfills and dumps is typically nutrient-rich, with elevated levels of nitrogen and ammonia compounds. Two common indicators used in tracking of leachate plumes are chloride and total dissolved solids (TDS). Iron levels are typically very high in leachate. Sodium is also likely to be elevated, as well as sulfate, total organic carbon (TOC), biological oxygen demand (BOD) and chemical oxygen demand (COD).

Less common constituents which may also be present include metals such as lead or chromium, and volatile or synthetic organic compounds associated with industrial solvents, such as trichloroethylene, tetrachloroethylene, and benzene.

The presence and concentration of these constituents in the ground water are dependent upon several factors that dictate the extent and character of the resulting ground water impacts, these factors include:

a. landfill size and age,
b. types and quantities of wastes produced in the area,
c. local hydrogeology, and
d. landfill design/landfilling techniques.

An effective ground water monitoring program is crucial for accurate determination of ground water degradation. Improperly located monitoring wells can result in the oversight of a contaminant plume, or certain parameters may not be observed in the ground water for many years, depending upon soil adsorption capacities and ground water gradient.

Hazardous Waste Sites. The Florida Department of Environmental Protection (FDEP) Waste Management Division sponsors several programs which provide support for contamination cleanup. There are over 400 documented contamination sites in the UEC Planning Area. These include locations in the Early Detection Incentive (EDI) Program, the Petroleum Liability and Restoration Program (PLIRP), the Abandoned Tank Restoration Program (ATRP), and other nonfunded programs. Locations and cleanup status can be obtained through the FDEP Waste Management Division.

Superfund Program Sites. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as Superfund, authorizes the U.S. EPA to identify and remediate uncontrolled or abandoned hazardous waste sites. The U.S. EPA has identified 11 Superfund sites in the planning area (Figure H-8). The National Priorities List (NPL), a subset of the most serious Superfund sites, targets sites considered to have a high health and environmental risk. There is only one NPL site in the UEC Planning Area: Florida Steel located in Indiantown.

Septic Tanks. Septic systems provide an easy method for on-site disposal of waste. Local public health units estimate there are 55,000 septic tanks in the planning area. However, septic tanks may threaten ground water resources used as drinking water sources. Ground water contamination by septic systems has been responsible for disease outbreaks and chemical contamination of drinking water (U.S. EPA, 1990).

In 1990, the Florida Legislature passed the Chapter 90-262, Laws of Florida. This bill prohibits new discharges, or increased loadings from existing sewage treatment facilities, into the Indian River Lagoon system, which includes almost all of St. Lucie and Martin counties. Elimination of existing discharges is required by July 1, 1995. The “No Discharge” bill also directs both the South Florida and St. Johns River water management districts to identify areas where the existing on-site sewage disposal systems (OSDS) are considered a threat to the water quality of the Indian River Lagoon. These studies have been completed to assist counties and municipalities in developing programs to provide centralized sewage collection and treatment facilities. Many of these septic tanks in the planning area have been identified as a threat to the water quality of the Indian River Lagoon.

Impacts to Water Supply

The costs and difficulty of removing a contaminant by a drinking water treatment plant can be considerable, depending on the material to be removed. The lime softening/filtration water treatment process, widely used throughout the area, is effective in removing microorganisms, most inorganics, hardness, manganese, and iron. It is only moderately effective at removing color, and poorly effective at removing nitrate, nitrite, THMs and THM precursors, VOCs, SOCs, pesticides, chlorides, sulfates and silver.

Many of the major contamination sources identified in the planning area can generate contaminants that are not easily treated by the lime softening process. Nitrate is generated by septic systems or by fertilizer application, benzene from leaking gasoline tanks, and VOCs and SOCs from various hazardous waste contamination sites. Treatment processes are available to remove these contaminants.

WATER TREATMENT TECHNOLOGIES

Several water treatment technologies are currently employed by the regional water treatment facilities in the UEC Planning Area. Higher levels of treatment may be required to meet increasingly stringent drinking water quality standards. In addition, higher levels of treatment may be needed where lower quality raw water sources are pursued to meet future demand. This section provides an overview of several water treatment technologies and their associated costs.

Lime Softening

Lime softening is used at 6 of the 12 existing regional water treatment facilities in the planning area. Lime softening treatment systems are designed primarily to soften hard water, reduce color and to provide the necessary treatment and disinfection to ensure the protection of public health.

Lime Softening Process

Lime softening refers to the addition of lime to raw water to reduce water hardness. When lime is added to raw water, a chemical reaction occurs that reduces water hardness by precipitating calcium carbonate and magnesium hydroxide. Disinfectant may be added at several places in the treatment process, but adequate disinfectant residual and contact time must be provided prior to distribution to the consumer. The lime softening process is effective at reducing hardness, but is relatively ineffective at controlling contaminants such as chloride, nitrate, trihalomethane (THM) precursors and others (Hamann *et al*., 1990).

Community public water supplies are required to provide adequate disinfection of the finished/treated water and to provide a disinfectant residual in the water distribution system. The use of free chlorine as a disinfectant often results in the formation of levels of trihalomethanes (THMs) that exceed the maximum contaminant level (MCL) of 0.10 mg/L. THMs are formed when free chlorine combines with naturally occurring organic matter in the raw water source.

Lime softening is ineffective in removing the chloride ion and only fairly effective at reducing total dissolved solids (TDS). Chloride levels of raw water sources expected to serve lime softening facilities should be below the chloride maximum contaminant level of 250 mg/L to avoid possible exceedences of the standard in the treated water. The current finished water TDS MCL is 500 mg/L. Concentrations above 500 mg/L in the treated water are acceptable so long as no other MCLs are exceeded.

Nitrate is not effectively removed by the lime softening process. Lime softening facilities with raw water sources with nitrate concentrations exceeding the MCL of 10 mg/L will probably require additional treatment to meet the standard.

Proposed Safe Drinking Water Act regulations for THMs and disinfection byproducts (DBPs) will require that many existing lime softening facilities modify their treatment processes to comply with the standards for these groups of compounds. Add-on treatment technologies that are effective at removing these compounds or preventing their formation include ozone disinfection, granular activated carbon (GAC), and air stripping.

Lime Softening Treatment Costs

Capital construction costs for lime softening treatment facilities tend to be similar to those of other treatment processes (Table 27). Lime softening's cost advantages are in operating and maintenance expenses, where costs are typically 10 to 20 percent less than for comparable membrane technologies (see Table 31). However, an increase in total hardness of the raw water source will require increased amounts of lime to maintain the same water quality. In addition, any free carbon dioxide present in the raw water must first be satisfied by the lime before any significant softening can occur, which will impact the costs associated with this treatment process.

Table 27. Lime Softening Treatment Costs.

Facility Size (MGD)	Capital Cost (per gal/day capacity)	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
3	$1.30	$.20	1.5	$.48	$.018
5	$1.25	$.19	2.5	$.45	$.018
10	$1.22	$.18	4.0	$.40	$.017
15	$1.00	$.15	6.0	$.33	$.016
20	$.90	$.13	8.0	$.30	$.016

Source: PBS&J, 1991, Water Supply Cost Estimates.

Reverse Osmosis

Reverse Osmosis (RO) technology has been used in Florida for a number of years. About 100 membrane treatment systems are operational in the state with a combined capacity of about 50 MGD. Major Florida public water supply RO facilities include Cape Coral, Venice, Sanibel, Englewood and Jupiter.

Reverse Osmosis Process

RO is a pressure-driven process that relies on forcing water molecules (feed water) through a semipermeable membrane to produce fresh water (product water). Dissolved salts and other molecules unable to pass through the membrane remain behind (concentrate or reject water). RO is capable of treating feed waters of up to 45,000 mg/L total dissolved solids (TDS). Most RO applications involve brackish feed waters ranging from about 1,000 to 10,000 mg/L TDS. Transmembrane operating pressures vary considerably depending on TDS concentration (Table 28). In addition to treating a wide range of salinities, RO is effective at rejecting naturally occurring and synthetic organic compounds, metals, and microbiological contaminants. The molecular weight cutoff (MWC) determines the level of rejection of a membrane.

Advantages of RO treatment systems include their ability to reject organic compounds associated with formation of THMs and other disinfection by-products (DBPs), small space requirements, modular type construction and easy expansion. Disadvantages of RO systems include high capital cost, requirements for pretreatment and post-treatment systems, high corrosivity of the product water, and disposal of the reject. RO is also less efficient than lime softening, so more raw water is needed to produce finished water.

Table 28. Reverse Osmosis Operating Pressure Ranges.

System	Transmembrane Pressure Operating Range (psi)	Feed Water TDS Range (mg/L)	Recovery Rates (%)
Seawater	800-1500	10,000-50,000	15-55
Standard pressure	400-650	3,500-10,000	50-85
Low pressure	200-300	500-3,500	50-85
Nanofiltration	45-150	Up to 500	75-90

Source: AWWA, 1990, Water Quality and Treatment.

Disposal of RO reject is regulated by the FDEP. Various disposal options include surface water discharge, deep well injection, land application and reuse. Whether a disposal alternative is permittable depends on the characteristics of the reject water and disposal site (letter dated December 12, 1990 from B.D. DeGrove, Point Source Evaluation Section, FDER, Tallahassee, FL).

Reverse Osmosis Costs

RO treatment and associated concentrate disposal costs for a typical South Florida system, (2,000 mg/L TDS, 400 PSI) are provided in tables 29 and 30. Variables unique to RO capital costs include system operating pressures and concentrate disposal, while variables unique to RO operations and maintenance costs include electrical power, chemical costs, membrane cleaning and replacement, and concentrate disposal.

Table 29. Reverse Osmosis Treatment Costs.

Facility Size (MGD)	Capital Costs (per gal/day capacity	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
3	$1.40	$.21	.40	$.46	$.23
5	$1.27	$.19	.40	$.43	$.23
10	$1.17	$.18	.50	$.41	$.23
15	$1.14	$.17	.63	$.40	$.23
20	$1.16	$.16	.78	$.30	$.23

Source: PBS&J, 1991, Water Supply Cost Estimates.

Table 30. Concentrate Disposal Costs.

Deep Well Disposal Facility (MGD)	Capital Cost (per gal/day capacity)	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)
3	$.58	$.087	0.5	$.032
5	$.44	$.066	0.5	$.024
10	$.40	$.060	1.0	$.022
15	$.37	$.056	2.0	$.020
20	$.30	$.045	3.0	$.016

Source: PBS&J, 1991, Water Supply Cost Estimates.

Methods of determining capital and O&M costs vary from utility to utility, and as a result, cost comparisons of treatment processes can be difficult (Dykes and Conlin, 1989). Site-specific costs can vary significantly as a result of source water quality, reject disposal requirements, land costs, use of existing water treatment plant infrastructure, etc. Detailed cost analyses are necessary when considering construction of RO water treatment facilities. As a general rule, however, RO costs are 10 to 50 percent higher than lime softening.

Membrane Softening

Membrane softening or nanofiltration (NF) is an emerging technology that is currently in use in Florida. Membrane softening differs from standard RO systems in that the membrane has a higher MWC, lower operating pressures and feed water requirements of 500 mg/L or less of TDS. One significant advantage of the membrane softening technology is its effectiveness at removing organics that function as THM and other DBP precursors. Given the direction of increasing federal and state regulation of drinking water quality, membrane softening seems to be a viable treatment option towards meeting future standards. A number of membrane softening facilities have been installed in Florida.

The costs associated with membrane softening are similar to those of reverse osmosis, with operations and maintenance expenses tending to be lower. Membrane softening treatment costs are shown in Table 31.

Table 31. Membrane Softening Costs.

Facility Size (MGD)	Capital Costs (per gal/day capacity	Engineering Cost (per gal/day capacity)	Land Requirements (Acres)	O&M Cost (per 1000 gal)	Energy Cost (per 1000 gal)
3	$1.33	$.20	0.40	$.44	$.159
5	$1.21	$.18	0.40	$.42	$.159
10	$1.12	$.17	0.50	$.40	$.159
15	$1.10	$.17	0.63	$.38	$.159
20	$1.06	$.16	0.78	$.37	$.159

Source: PBS&J, 1991, Water Supply Cost Estimates.

Electrodialysis and Electrodialysis Reversal

Electrodialysis (ED) is an electrochemical process that involves the movement of ions through anion- and cation-selective membranes from a less concentrated solution to a more concentrated solution by the application of direct electrical current. Electrodialysis reversal (EDR) is a similar process but provides for the reversing of the electrical current which causes a reversing in the direction of ion movement. ED and EDR are useful in desalting brackish water with TDS feedwater concentrations of up to 10,000 mg/L. ED/EDR, however, is generally not considered to be an efficient and cost-effective organic removal process and therefore is usually not considered for THM precursor removal applications (AWWA, 1988). Available cost data for ED/EDR is limited, but for the same area appear to be 5 to 10 percent higher than RO treatment (Boyle Engineering, 1989).

Distillation

The distillation treatment process is based on evaporation. Saltwater is boiled and the dissolved salts, which are non-volatile, remain behind. The water vapor is cooled and condenses into fresh water. Two distinct treatment processes are in use: multistage flash (MSF) distillation and multiple effect distillation (MED). Capital construction costs and operation and maintenance expenses are three to five times as expensive as brackish water RO systems and/or EDR (Buros, 1989).

WATER TREATMENT FACILITIES

Potable Water Treatment Facilities

Potable water in the UEC Planning Area is supplied by three main sources: (a) regional water treatment facilities, municipal or privately owned; (b) small developer/homeowner association or utility owned water treatment facilities; (c) self-supplied individual wells that serve individual residences. Many of the smaller facilities are constructed as interim facilities until regional potable water becomes available. At that time, the smaller water treatment facility is abandoned upon connection to the regional water system.

There are 12 existing regional water treatment facilities within the planning area. In addition, there is a proposed facility and service area in Martin County (Figure 19). All of these facilities use raw ground water, and most are considering ground water sources to meet future demands. Wellfield locations for these facilities are shown in Figure 20.

Detailed maps showing the location of each treatment facility and associated wellfields are provided in Appendix E. Other detailed information provided in the appendix includes the source aquifer and pump capacity for each of the wells; existing, proposed, and future sources of raw water; and water treatment methods for each facility.

The existing treatment technologies employed by the facilities are lime softening, reverse osmosis, membrane softening and chlorination. Of the 12 existing facilities, 5 use lime softening exclusively, 2 use a membrane technology exclusively, 4 use aeration, and 1 uses a combination of lime softening and membrane technology. More stringent future drinking water standards (see Chapter 6), combined with deteriorating water quality and decreasing available freshwater supplies, may necessitate that greater emphasis be placed on nonconventional methods of treatment (e.g., membrane technologies) and alternative raw water sources (e.g., brackish/saline water).

Public water systems in the UEC Planning Area are regulated by the Florida Department of Environmental Protection (FDEP) for all facilities, with the following exceptions: (1) those water systems that have less than 15 service connections; or (2) facilities which regularly serve less than 25 individuals daily at least 60 days out of the year; or (3) facilities which serve at least 25 individuals daily less than 60 days out of the year. All other systems in are regulated by the local health departments (Chapter 62-550, F.A.C.).

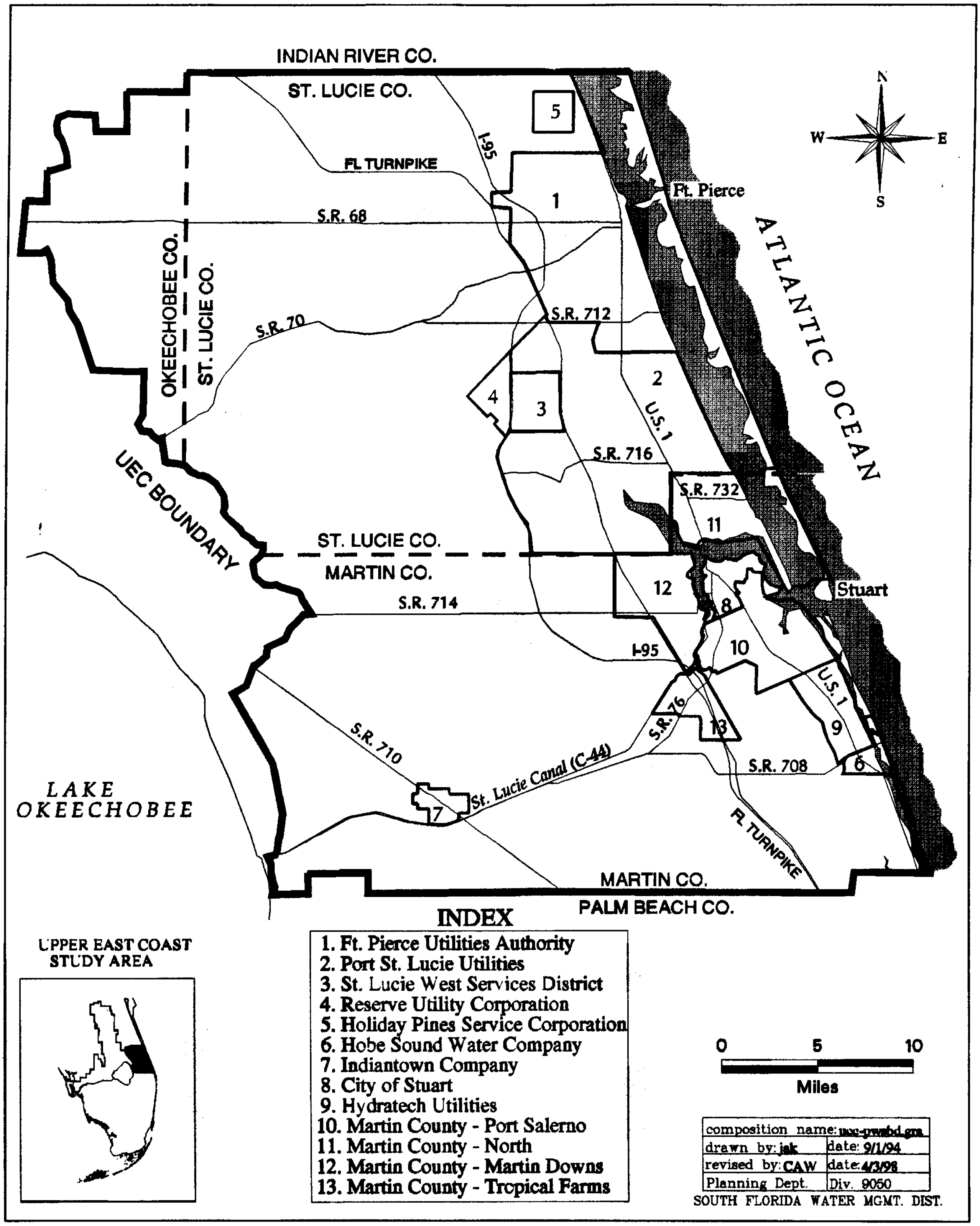

Figure 19. Regional Potable Water Treatment Facility Service Areas.

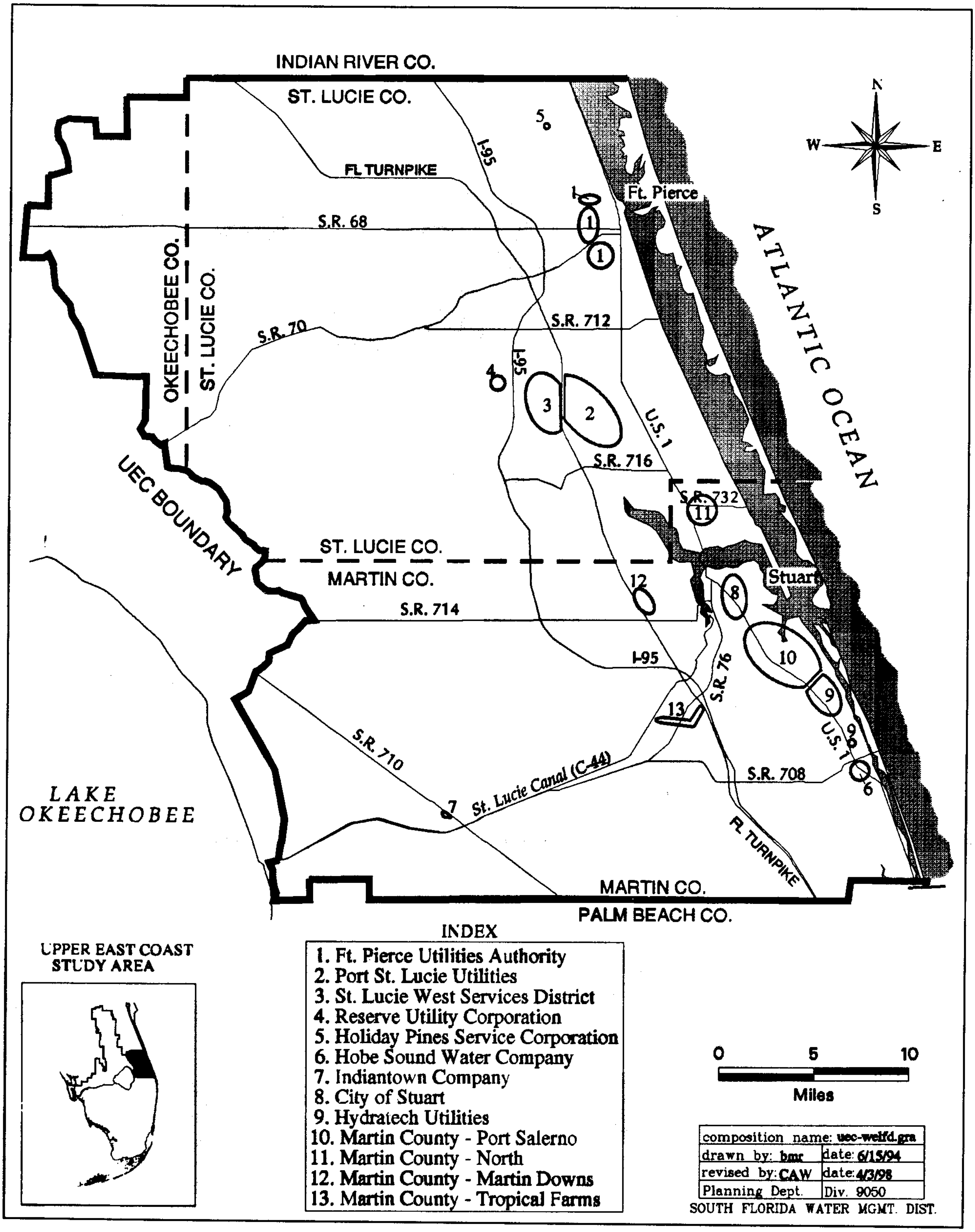

Figure 20. Location of Wellfields for Regional Potable Water Treatment Facilities.

Wastewater Treatment Facilities

Wastewater treatment in the UEC Planning Area is provided by: (a) regional wastewater treatment facilities, municipal or privately owned; (b) small developer/homeowner association or utility owned wastewater treatment facilities; and (c) septic tanks. There are approximately 170 wastewater treatment facilities permitted by the FDEP with approved capacities between 0.005 and 9 MGD in the planning area. Of these, 12 facilities have an existing or 2010 proposed capacity of 0.50 MGD or greater. Many of the smaller facilities are constructed on an interim basis until regional wastewater becomes available, at which time the smaller wastewater treatment facility is abandoned upon connection to the regional wastewater system. The regional wastewater service areas are shown in Figure 21.

All the facilities use the activated sludge treatment process. The methods of reclaimed water/effluent disposal include surface water discharge, reuse, and deep well injection. One facility uses a surface water discharge to the Indian River and four facilities use deep well injection systems. The methods of reclaimed water disposal via reuse include golf course, residential lawn, and other green space irrigation, and ground water recharge by percolation ponds.

Specific information on each of these regional facilities is provided in Appendix E. The information includes summaries of the existing, proposed, and future wastewater treatment and disposal methods. Capacity and reuse feasibility for each facility, as well as future plans are also discussed.

Wastewater treatment in the planning area is regulated by the FDEP for all facilities. The following wastewater treatment facilities are exempt from FDEP regulation: (1) those with a design capacity of 2,000 GPD or less which serve the complete wastewater and disposal needs of a single establishment; or (2) septic tank drainfield systems and other on-site sewage systems with subsurface disposal and a design capacity of 5,000 GPD (3,000 GPD for restaurants) or less, which serve the complete wastewater disposal needs of a single establishment. All other systems are regulated by the local health department for each county (Chapter 62-600, F.A.C.).

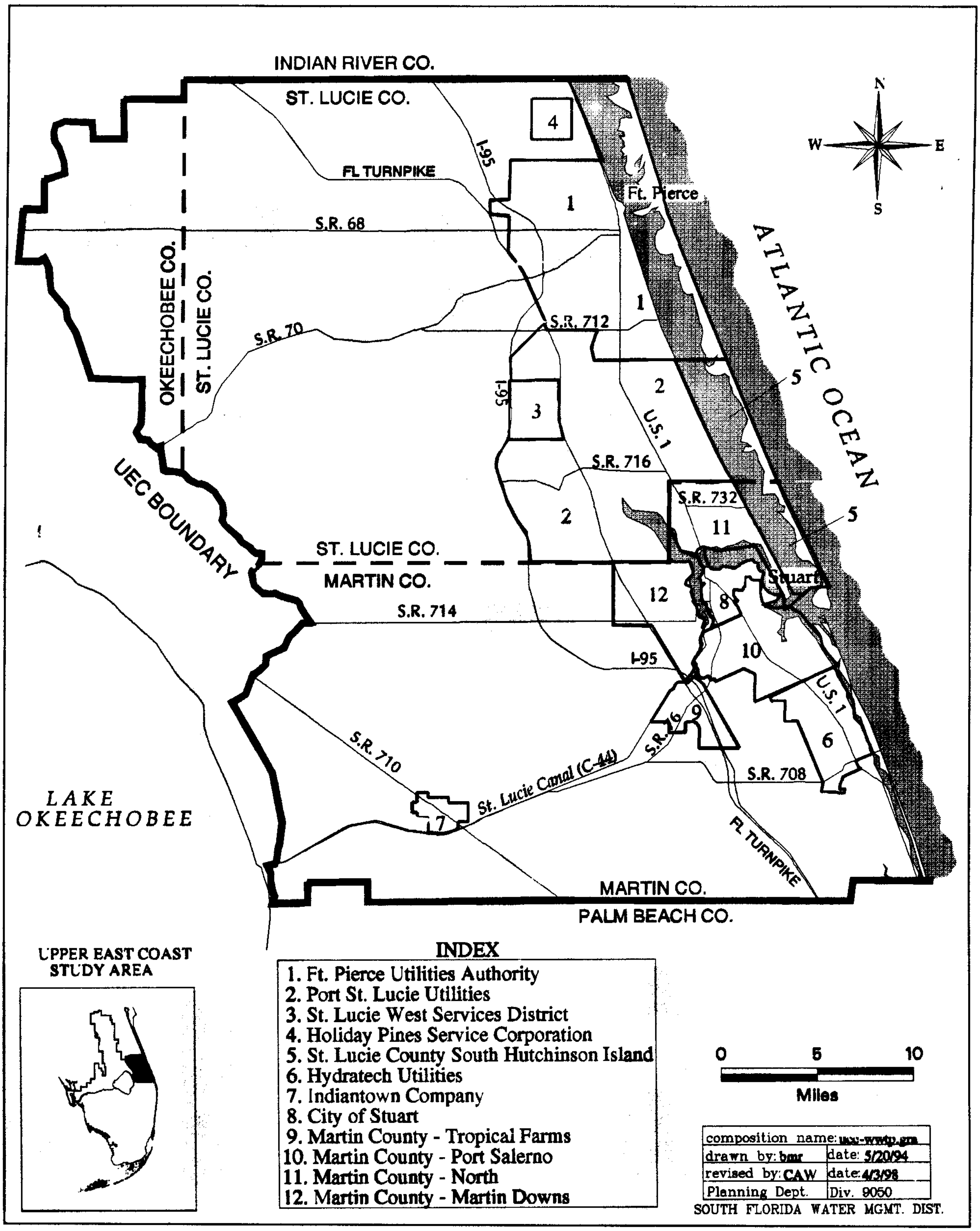

Figure 21. Regional Wastewater Treatment Facility Service Areas.